

## Carbohydrates

Carbohydrates are the primary energy molecule for the human body. The body can obtain energy from lipids and proteins, but carbohydrates are used first if they are available. Carbohydrates are easily broken down by the body; as they are broken into smaller and smaller molecules, the energy stored in the carbohydrate molecule is captured and ultimately transferred to another molecule called adenosine tri-phosphate (ATP). ATP is the actual energy source for all cell processes including communication, growth, repair, and reproduction. To convert the energy in a carbohydrate molecule to an ATP requires the action of several proteins (enzymes) and oxygen.

Similar to lipids, carbohydrates consist of oxygen, hydrogen and carbon atoms. The difference between the macromolecules is in the ratio of the atoms. Carbohydrates usually have a ratio of 1 carbon: 2 hydrogen: 1 oxygen. Lipids have far fewer oxygen atoms and do not have a consistent ratio of the atoms.

Unlike lipids, carbohydrates are polymers. The building block, or monomer, of a carbohydrate is a sugar molecule, also known as a saccharide. How many sugar molecules do you think are in a monosaccharide? \_\_\_\_\_ How many do you think are in a disaccharide? \_\_\_\_\_ Read on to see if your predictions are correct.

### Monosaccharides

The simplest carbohydrates are simple sugars which are made of only one monomer and are called monosaccharides. Examples of monosaccharides include glucose, fructose, galactose, deoxyribose and ribose. Glucose is a common sweetener used in foods and is the primary building block of many complex carbohydrates that are essential for our bodies. Fructose is the simple sugar found in many fruits. Deoxyribose and ribose are the sugar molecules used to form deoxyribonucleic acid (DNA) and ribonucleic acid (RNA) that you will study later in units 4 and 5.

## Understanding Carbohydrates

1. Go to the Western Kentucky University website for Biology 113, Carbohydrates Accessed May 21, 2008 and available at:

<http://bioweb.wku.edu/courses/BIOL115/Wyatt/>.

Click on Biochemistry; Follow the link to CARBOHYDRATES. Note if you click on the red stars, additional information is displayed.

2. Read the information on carbohydrates. *Take notes in your Laboratory Journal.*
3. Build a glucose molecule in the ring formation using the model kit. Use the diagrams on the Carbohydrates page you just read. *You may find it easier to first build the glucose as the straight or stick model and then link the ends to form the ring.*
4. Compare your model to the pictures on the web page.
5. **Sketch the model of the glucose in the ring formation *in your lab journal*. Be sure to label all parts. (Remember the sketch is not meant to be an exact drawing; it is a study tool so you can look at it later and remember what your model looked like.)**

## Dehydration Synthesis and Hydrolysis

In order to combine the subunits of proteins, lipids, and carbohydrates, a process known as *dehydration synthesis* is used. Without reading further, predict what this term might mean by taking the term apart and thinking about the word *dehydration* by itself and the word *synthesis* by itself.

6. **Write your prediction of the meaning of the term *dehydration synthesis* in your lab journal.**

In order to break a macromolecule apart to use the subunits to make other products or to obtain energy, a process called *hydrolysis* is used. Without reading further, predict what this term might mean. Take the word apart and consider the meanings the terms of *hydro* and *lysis*.

7. **Write your prediction of the meaning of the term *hydrolysis* in your lab journal.**
8. Go to the Lone Star College North Harris Biology website to view the page on dehydration synthesis and hydrolysis. Accessed May 21, 2008 and available at:  
<http://nhscience.lonestar.edu/biol/dehydrat/dehydrat.html>. Use the dehydration synthesis and hydrolysis buttons for each type of macromolecule to view the animations. Take notes in your Laboratory Journal or notebook.
9. Go to the Western Kentucky University website for Biology 113, Macromolecules (Biochemistry) Accessed May 21, 2008 and available at:  
<http://bioweb.wku.edu/courses/biol115/Wyatt/Biochem/macromolecules.htm>. Note: if you click on the red stars, additional information is displayed.
10. Click on the large red spot near the white space on the page. Watch the animation that appears. Take notes in your Laboratory Journal or notebook.
11. **Write a definition for dehydration synthesis *in your lab journal*.**
12. **Write a definition for hydrolysis *in your lab journal*.**

## Disaccharides

Two monosaccharides can combine to form one new molecule, called a disaccharide. Were your predictions of the meanings of the words *monosaccharide* and *disaccharide* accurate?

Examples of disaccharides include maltose (two linked glucose molecules), sucrose (glucose linked to fructose), and lactose (glucose linked to galactose). Maltose is a sugar commonly found in seeds and is used to make malted candy (malted milk balls) or drinks (malted milkshake). You may have eaten sucrose this morning in your coffee or on your cereal; it is common table sugar. If you had milk on your cereal, then you probably ate lactose this morning because it is the sugar found in cow's milk. If you used soy or rice milk, then you did not eat any lactose because these products do not contain lactose. For that reason they are good alternatives for people who are allergic to cow's milk or are lactose intolerant. Soy and rice milk are both sweetened during their manufacturing process by the addition of sucrose.

13. Work with another pair of students and combine your glucose molecule with theirs to form the disaccharide maltose. Follow the description and diagrams on the website you accessed in step 41. When you roll the mouse cursor over the diagrams of the two glucose molecules, an animation will show the dehydration synthesis process.
14. Compare your model of maltose to the picture on the website and be sure it is accurate. Keep your maltose molecule assembled.
15. **Use colored pencils and sketch the model of the disaccharide you built in the space below. Be sure to label all parts. (Remember the sketch is not meant to be an exact drawing; it is a study tool so you can look at it later and remember what your model looked like.)**
16. Read the next section about polysaccharides. *Be able to discuss how polysaccharides are used to store energy in liver and muscle cells, and are broken down as needed to provide energy for the body.*
17. Follow your teacher's directions to either disassemble the molecule or to save it to use later.

## Polysaccharides

Polysaccharides contain hundreds or even thousands of monosaccharides linked together by dehydration synthesis to form long chains. These carbohydrates do not taste sweet and are insoluble in water. Animals, including humans, combine multiple glucose molecules to form glycogen which is stored in the liver and muscle tissue for use as an energy source. When energy is needed, the glycogen is broken down into multiple glucose molecules. The glucose molecules are further broken down and the energy stored in the molecule is used to produce ATP, the energy molecule used by all cells.

Plants combine multiple glucose molecules to form a different polysaccharide for energy storage, starch. Humans can digest plant starches found in rice, potatoes, wheat, and corn into their component glucose molecules and use these glucose molecules for energy or to build new carbohydrates. Plants also combine multiple glucose molecules to form the structural polysaccharide, cellulose. Humans can not digest or breakdown cellulose, so it is considered a fiber.

18. Read the next section about Energy Conversions. Be able to describe how the energy in macromolecules, especially carbohydrates, is captured for use in your body

## Energy Conversions

The human body depends upon many chemical reactions occurring at the same time. Synthesis reactions are those that combine atoms or molecules together to make a new product. All synthesis reactions, collectively in the body, are referred to as *anabolism*. These reactions absorb more energy than they produce. The creation of glycogen is an example of an anabolistic reaction. The energy of many small molecules is combined into a large one. You may have heard the term *anabolic steroids*; these are hormones that cause the body to build tissue, especially muscle. That is why some athletes have taken them to gain an unfair advantage.

The opposite of anabolism is *catabolism*. It is the decomposition (or breaking apart) of large molecules into smaller ones. During catabolism, more energy is released than absorbed. The breakdown of a starch molecule into its component glucose molecules is an example of catabolism. During both anabolism and catabolism, an energy exchange occurs.

In some instances, one type of molecule is used to store the energy and a different molecule is the actual energy source. To understand this principle better, let's use an analogy about gasoline. Gasoline is derived from crude oil. Energy is stored in the crude oil, but automobiles do not run on crude oil. The energy in the crude oil molecules is unusable until the oil is refined or processed. The refining breaks down the oil into smaller molecules of gasoline. The gasoline is then burned to provide energy to the engine of the car.

Just as crude oil must be broken down into gasoline so it can provide energy to the car, the human body must breakdown food particles into the macromolecules (digestion), then breakdown the macromolecules to obtain energy usable by cells (cellular respiration).

After we consume our food, it is digested into its component parts. The preferred macromolecule to use as an energy source is carbohydrate. Carbohydrates are further broken down into their component sugar molecules. Many carbohydrates are formed by linking glucose molecules, so they are broken down into multiple glucose molecules and absorbed into the blood stream from the small intestine. The glucose molecules travel to the body's cells where a series of chemical reactions, known as cellular respiration, ultimately make adenosine tri-phosphate, ATP. Using the analogy of a car, ATP is the human body's gasoline. It is the compound that powers all metabolic reactions. Without ATP we would not be alive.

## Conclusion

1. How do monosaccharides, disaccharides and polysaccharides differ in structure?
2. Sugar dissolves in water. Think back to the discussion about bonding and polarity. Sugar is not an ionic substance. What kind of bonds must be in this molecule? Explain your answer.
3. In a chemical reaction the substance of primary importance that is created is referred to as the *product* and other substances that result are called the *by-products*. When you linked the two glucose molecules together, what was the *product* you created?
4. What was the by-product when you linked the two glucose molecules together?
5. Based on what you have now learned about biochemistry, predict which one of the three types of carbohydrates (monosaccharide, disaccharide, or polysaccharide) would have more energy stored in its structure. Explain your answer.
6. Some people might argue that an orange is a high energy food. Others would disagree, and consider pasta to be a high energy food. How is it possible for both of groups of people to argue their position? Who is really correct based on the biochemistry of the molecules involved? Explain your answers.
7. Describe two reasons why having a basic knowledge of biochemistry is important for everyone.